

AD-A204 947

RSRE
MEMORANDUM No. 4243

ROYAL SIGNALS & RADAR ESTABLISHMENT

AUTOMATIC COMMUNICATIONS CHANNEL
INTERFERENCE MONITORING

Author: N G Smith

**BEST
AVAILABLE COPY**

PROCUREMENT EXECUTIVE,
MINISTRY OF DEFENCE,
RSRE MALVERN,
WORCS.

DTIC
ELECTE

23 FEB 1989

E

89 2 23 016

UNLIMITED

ROYAL SIGNALS AND RADAR ESTABLISHMENT

Memorandum 4243

TITLE: AUTOMATIC COMMUNICATIONS CHANNEL INTERFERENCE MONITORING

AUTHOR: N G Smith

DATE: April 1988

SUMMARY

This memorandum describes a system that monitors a communications channel and logs details of interfering signals. An overview of the system hardware configuration and a detailed description of the software is provided. The system consists of software for logging signals that occur in the channel and independent software for analysis of the logged data.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input checked="" type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



Copyright
C
Controller HMSO London
1988

Contents

- 1 Overview
 - 1.1 Overall Requirement
 - 1.2 System Requirement
 - 1.3 System Design
 - 2 Monitoring Software 'INTLOG'
 - 2.1 Software Function
 - 2.2 Hardware Requirement
 - 2.3 Software Description
 - 2.3.1 Functional Decomposition And Software Flow
 - 2.3.2 Parameters Initialization
 - i. Calibration Parameters
 - ii. User Parameters
 - 2.3.3 Setup Spectrum Analyser
 - 2.3.4 Calibration Of The Reference Level On The Spectrum Analyser
 - 2.3.5 Video Average Samples
 - 2.3.6 Reading Data From The Video Average Display
 - 2.3.7 Analysis Of Channel Spectrum Data
 - 2.3.8 Graphical Display Of Data
 - 2.3.9 Logging Monitored Data
 - 2.3.10 Storing Monitored Data Into A File
 - 3 Statistical Analysis And Display Software 'INTDISP'
 - 3.1 Software Function
 - 3.2 Software Description
 - 3.2.1 Functional Decomposition And Software Structure
 - 3.2.2 Reading Data
 - 3.2.3 Storing Data
 - 3.2.4 Analysis
 - i. Parameters
 - ii. Types Of Output
 - iii. Output Statistics
 - 4 Conclusion And Further Development
 - 4.1 Conclusions
 - 4.2 Software Enhancements
 - 4.3 Software Developments
-
- Appendix A. Finding The Noise Level Of A Channel
 - Appendix B. Converting From Power To Signal To Noise Density
 - Appendix C. Determining A Level For Each User defined Frequency Slot
 - Appendix D. Comparison Of Norms For Measuring A Noise Level
 - Appendix E. Software Statistics
 - Appendix F. Example Of Input Parameters For 'INTLOG'
 - Appendix G. Example Of Display For 'INTLOG'
 - Appendix H. Example Of Analysis Parameters For 'INTDISP'
 - Appendix I. Examples Of Output Statistics From 'INTDISP'

1 Overview

1.1 Overall Requirement

To produce an automated system to monitor a communications channel and record the details of interfering signals present in the channel.

1.2 System Requirement

The System to fulfill the above requirement was specifically designed to monitor a channel where users occupy the channel in Time Division Multiple Access (T.D.M.A.). Monitored data is stored and analysed separately using distinct pieces of software, 'INTLOG' is the monitoring software and 'INTDISP' is the analysis and display software.

1.3 System Design

The system configuration shown in figure 1.1 describes the hardware and software relationship.

The system configuration is shown using two computers: This enables analysis to be performed at the same time as the data monitoring. The system can be run with a single computer but then monitoring and analysis cannot be performed in parallel.

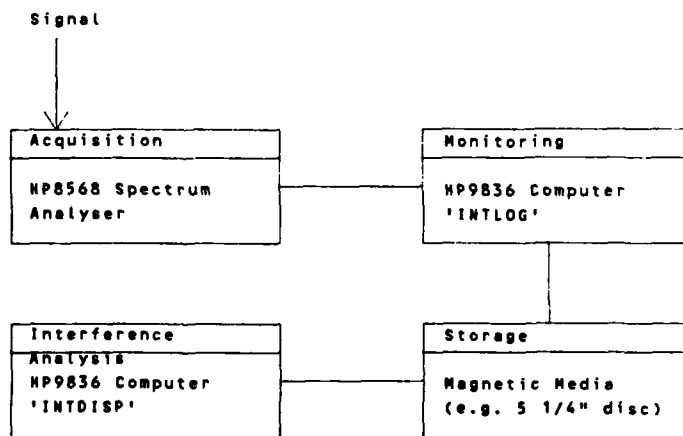


Figure 1.1 - System Configuration

2 Monitoring Software 'INTLOG'

2.1 Software Function

The software 'INTLOG' monitors the channel in quarter hour segments. Using operator defined parameters to define resolution, the software logs the details of any interference.

For each user defined frequency slot, every quarter of an hour a record is made of the length of time during that monitoring period that an interferer occurred at discrete signal to noise density (S.N.D.) levels. A two dimensional array of data is recorded into a separate data file for each monitoring period. The data can then be read by INTDISP (complementary software to INTLOG) which will display (and output) the data in many different forms, according to the information required.

2.2 Hardware Requirement

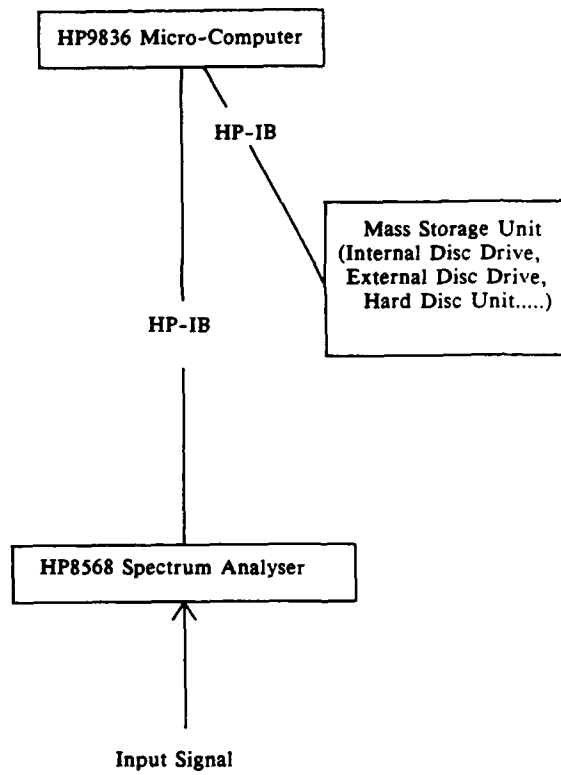


Figure 2.1 - Representation Of Hardware Required For Operation Of 'INTLOG'

2.3 Software Description

2.3.1 Functional Decomposition And Software Flow

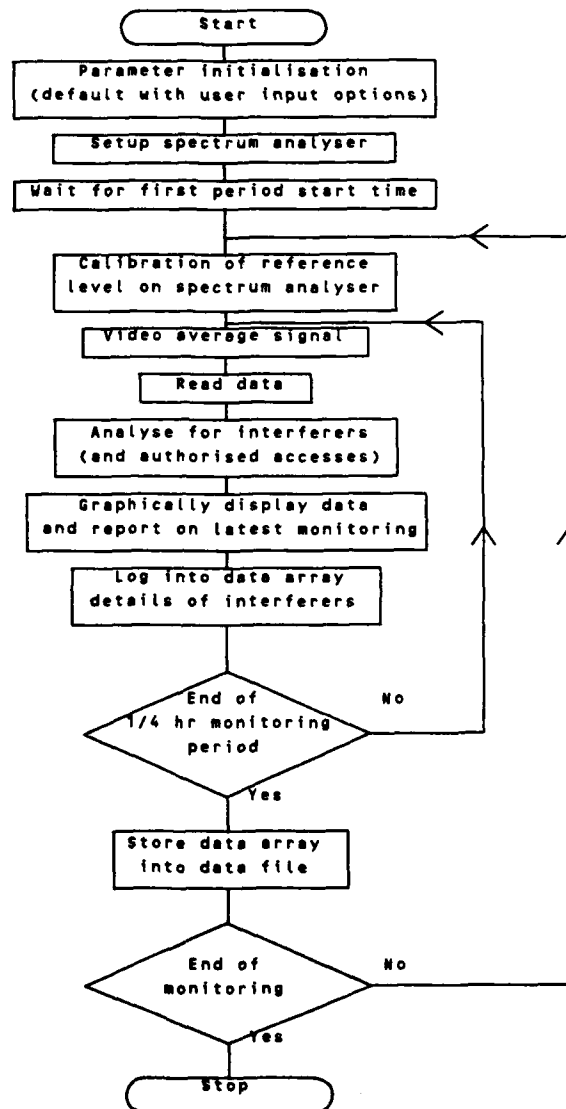


Figure 2.2 - Functional Flow Chart

S.N.D. resolution (dBHz) :

The level of any interference is given as being within a S.N.D. slot, (i.e. between the minimum and maximum dBHz of that slot), rather than an exact value. This enables more economic storage of the recorded data.

ii. User Parameters

Time and date :

Displayed in the top right hand corner of the screen and regularly updated, this is internally generated and need only to be reset when the computer is first switched on. This time is used as the reference to start monitoring periods and should be entered accurately.

Filename prefix :

The data files used to store the monitoring results are sequentially named files with the prefix entered and a suffix taken from the monitoring period number (starting from zero). When the prefix is entered the first data file (prefix(0)) is checked to ensure it does not already exist. It is assumed that if this file does not exist then subsequent versions in the sequential list also do not exist (note that an error will be produced if they do).

Start time and date of monitoring :

This is calculated as the next whole quarter hour cycle to occur, but can be set to any time and date later than the actual time and date. If the start time is missed, the software will wait for the next quarter hour and continue for the number of periods required (i.e. the number of sampling periods will not be reduced).

Duration of monitoring (finish time) :

Either, the number of periods (quarter hours) can be entered and the finish time will reflect this value or the finish time and date can be set and the number of sampling intervals will be set from this value.

2.3.3 Setup Spectrum Analyser

Setting the spectrum analyser involves first checking that the analyser is not in any error mode (e.g. external reference missing), by doing a serial poll of the device, and interrogating the status byte. If there is an error the user is warned and the program will not proceed until the error is cleared (every 4 seconds the analyser is rechecked until the error is cleared).

Once the analyser is found to be error free the calibration parameters are set on the analyser.

2.3.2 Parameter Initialization

The definable parameters in the software are split into 2 groups: calibration parameters and user parameters.

The first group, (calibration parameters), deal with aspects concerning the channel to be monitored. The second group, (user parameters), define the monitoring period and data file name to be used.

The parameters are initially read from a default file which can be updated to contain the latest user defined values. Choice is given to change the parameters via softkey commands, which when used prompt for the relevant value, (the prompt includes the required resolution and units for each input values).

i. Calibration Parameters

Centre frequency (MHz) :

Indicates the centre of the monitoring band, as well as the value sent to the spectrum analyser as its centre frequency.

Frequency range (kHz) :

The maximum and minimum frequencies of the center of the frequency slots, (that can be accommodated by the frequency range using the step size (width) defined) are displayed. The reference slot is a single slot in the center of the band, thus there is always an odd number of slots.

Resolution bandwidth (kHz). Video bandwidth (kHz). Sweep (msec) :

These are all directly relevant to the analyser display and can often best be set by using the auto function of the analyser and then entering the values into the software. If the values are not entered the software will reset them to the values in the parameter list. The Spectrum Analyser users manual should be referred to for the use of these functions.

Video averages :

Video averaging can be used and the resulting averaged signal is the signal analysed for interferers. It is up to the user to define the number of averages, with due consideration to the advantages of averaged noise and the possibility of diminishing the level of a high level, but short period, interfering signal.

Threshold level (dBHz) :

This level determines the minimum S.N.D. level at which any signal is recorded as interference.

Maximum level (dBHz) :

This level defines the upper limit of any recorded S.N.D. levels and if exceeded a value is recorded as being at this level. Thus any values in the top S.N.D. slot should be regarded as equal or greater than, not just equal to as other slots should.

2.3.4 Calibration Of The Reference Level On The Spectrum Analyser

At the beginning of each monitoring period the reference level on the spectrum analyser is reset to allow for any variation in the noise level.

The procedure used to set the reference level is to take a video average of as many samples as the user selects, then measure the noise level of the channel, and then set the reference level to 45 dB above this. The process is repeated until consecutive levels differ by less than 5 dB. This process avoids two problems; firstly when an unusual signal arbitrarily biases the noise level measurement, and secondly when the noise level is outside the spectrum analyser's display limits.

2.3.5 Video Average Samples

The software initiates the video averaging of the required number of samples with a straightforward command to the analyser. When the analyser has finished the required number of averages it produces an interrupt to which the software reacts. The status byte of the analyser is then checked to ensure the interrupt was for the required reason (an error message will occur otherwise, but then the software will continue) and then the interrupt is reset and the software continues.

2.3.6 Reading Data From The Video Average Display

The video average display is read using a single element transfer mode. This enables data to be transferred with power (y axis) values expressed in dBm's.

2.3.7 Analysis Of Channel Spectrum Data

Using the spectrum output from the analyser, the channel is first reduced to 'S.N.D. against frequency' (which corresponds to frequency slots defined by the user). The process of reducing the data to this form involves three steps:

- i. Find the noise level of the channel.
- ii. Convert from power to S.N.D..
- iii. Determine the level for each user defined frequency slot.

In order to identify authorized accesses, the S.N.D. data are compared with a simple model. This model describes the minimum S.N.D. of an authorized access over the frequency range of that authorized access. If the channel has a S.N.D. level greater than that given by the model then it is assumed an authorized access is present on the channel. The software continues whether an authorized access is present or not, and sets the 'authorized access present' flag as necessary.

The next stage is to quantize the S.N.D. level for each frequency slot. The S.N.D. equivalent to the signal level is converted to an index, which corresponds to the number of S.N.D. increments above the threshold level. The first S.N.D. level is at index one and a zero index indicates the level is below the threshold value.

2.3.8 Graphical Display Of Data

After each sample has been analysed a graphical display is produced in the form of a bar graph. This bar graph overlays a grid, which displays the resolution of both the S.N.D. and the frequency.

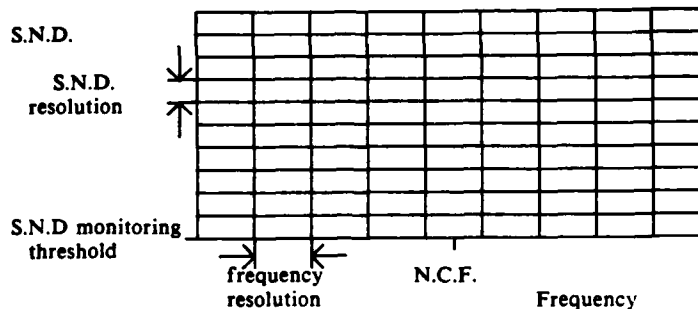


Figure 2.3 - Display Output Grid Of 'INTLOG'

Also displayed is a short message indicating the existence of; an authorized access, interference or an empty channel. When an authorized access is present the bar graph is plotted in blue otherwise it is plotted in red (this gives easy visual indication of the state of the channel in the last sample).

2.3.9 Logging Monitored Data

After each sample has been analysed the results are logged into a two dimensional array. The length of time over which the sample was collected is recorded, and this length of time is cumulatively added to any element of the (S.N.D., frequency) array for which an interferer was detected.

Also recorded is the total length of time that valid interference monitoring (in any period) takes place (i.e. when no authorized access is present). The total time authorized accesses were present are also recorded giving a total picture of the channel activity during a monitoring period.

2.3.10 Storing Monitored Data Into A File

When a monitoring period is completed, the record of the sampling times and parameters of the sampling, are stored into a data file along with the two dimensional (S.N.D., frequency) array of monitored interference occurrences.

Only at the end of a monitoring period is the data file created and the data stored, then the file is closed. This enables the files to be accessed at other times to do intermediate analysis of the results (e.g. use INTDISP to review data collected up to this point). This facility also gives the opportunity to replace the mass storage media if it is full (e.g. put in a new floppy disc).

3 Statistical Analysis And Display Software 'INTDISP'

3.1 Software Function

INTDISP is the complementary software to INTLOG. Its purpose is to enable analysis of the data recorded by INTLOG. The data can be analysed using a variety of techniques according to the information required by the user. The analysed data can be output in graphical form (2 or 3 dimensional representation) or in a tabulated form (displayed on the screen or output onto a printer).

Another function of INTDISP is to rationalize the sequential data files created by INTLOG. This produces a single 'mass' data file containing all of the monitoring parameters and data, which is more economical with storage as it only requires a single record of the sampling parameters.

3.2 Software Description

3.2.1 Functional Decomposition And Software Structure

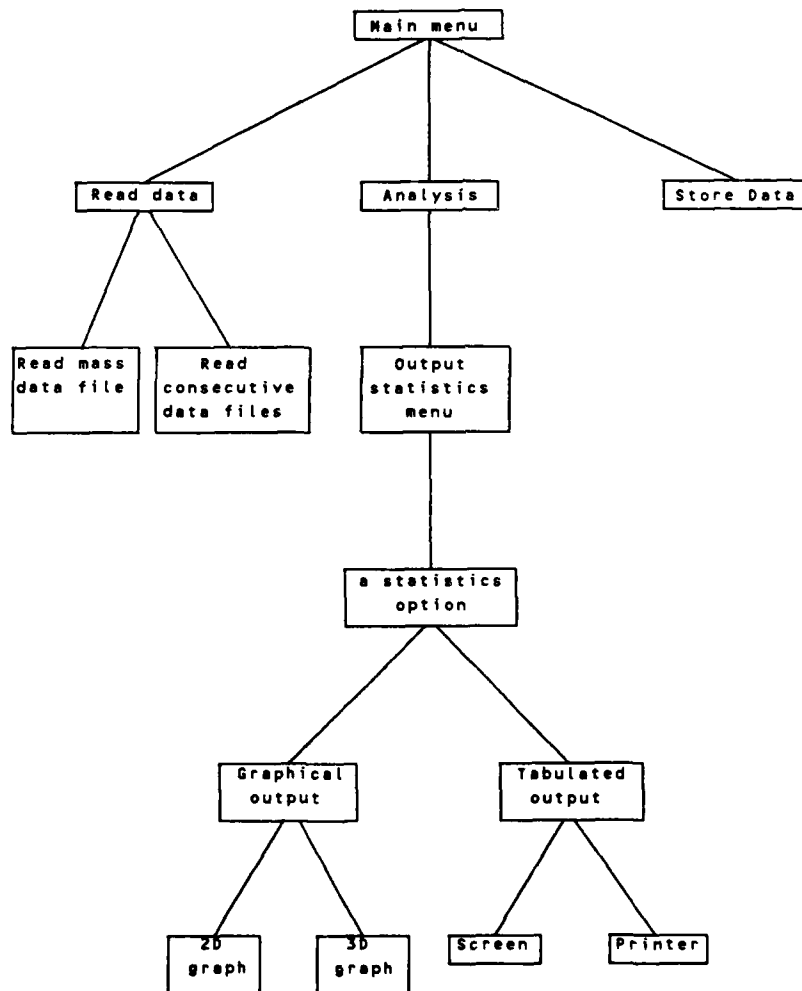


Figure 3.1 - Software Structure for 'INTDISP'

3.2.2 Reading Data

Data for INTDISP is either read from consecutive files created by INTLOG, or a single 'mass' file created by INTDISP from these consecutive files. Records of data within INTDISP are identical wherever they may have been read from, thus making no effect on the rest of the software.

For INTDISP to read the data files it is required that the user enters the file name. The file name, if consecutive files are being used, is the prefix as entered in INTLOG ('file_prefix'). Also the number of consecutive files must be entered (n), thus these files must begin with 'file_prefix'(0) and end with 'file_prefix'(n-1). If a single mass file is being used, as created by INTDISP, then the complete file name must be entered. When prompted for the number of files a zero is entered to indicate a mass file.

3.2.3 Storing Data

Store data is used to store all of the present data into a single 'mass' file. This is usually done to rationalize a group of consecutive files but could be used to make a copy of the mass file currently in use. A prompt occurs for a file name and the file is stored under this name. If the file already exists it will not be over written, but the prompt will be repeated. A mass file contains all of the information that is contained within the group of consecutive files, thus after creation of the mass file, the consecutive set of files may be deleted (purged).

3.2.4 Analysis

When the analysis option is chosen from the main softkey menu another softkey menu replaces the main menu with the types of analysis (output statistics) that can be performed.

i. Parameters

When any of the analysis options are selected two parameter lists are displayed on the screen.

On the left hand side of the screen are listed the 'Data Parameters'; these are a standard list of the parameters used when the data was sampled using INTLOG. The data parameters are the same for all the options and are displayed as a guide to values that could be entered to alter the default calculation parameters.

The 'Variable Parameters' give a specialized list of parameters that are relevant to the type of analysis chosen. The variable parameters can be altered using softkey options, and the value entered must be within the possible range for that parameter or it will not be accepted. When the variable parameters are as required the 'SET' softkey should be used to indicate this, and then the output values are calculated.

The use of these parameters include controlling the range of values that calculations are performed over. For example the S.N.D. threshold level could be increased to include only

interfering signals of a greater level, or the frequency range of the output data or the calculations, can be reduced. The calculations in statistical output are strictly within the parameters that the user defines, and these ranges are displayed on any output. The setting of the maximum to the minimum of a range will give information about a single value.

ii. Types Of Output

When the output values have been calculated the user is given the option of how to convey these values. The output can be in a graphical or tabulated form.

The situation where no monitoring data was collected (e.g. an authorized access was present on the channel for the whole monitoring period), is dealt with by either displaying a band in a contrasting colour for a graphical output, or outputting asterisks in a tabulated output.

Graphical :

The graphical output can be either a two or three dimensional representation of a bar graph, depending on the form of the output. Each output graph has all its axes labeled indicating the appropriate units. There is also a title to explain the graph, thus no ambiguity about the contents should exist when viewing the graph on its own.

The 3D representation of a bar graph has a 3D square column to represent each value; these columns are displayed in solid colour. A further facility enables the graph to be viewed with a left or right hand projection.

Tabulated :

A table of values can be output to the printer or displayed on the screen. The printer output uses compressed print to enable all of the data for each row to fit on a single line (in most cases). The form of the tabulated values is generally that each row represents a separate time segment and each column represents a slot in frequency or S.N.D. depending upon the statistics being output. As with the graphs the tables are titled and fully labelled to enable them to be used as a reference on their own. The facility is given to print the data and calculation parameters used onto the printer.

iii. Output Statistics

f vs l vs t :

('Frequency from N.C.F. (kHz)' vs 'S.N.D. Level (dBHz)' vs 'time')

The values calculated for this output are the mean S.N.D. level of interferers at each frequency during each time segment. Note this is the mean of the S.N.D. levels that exceed the threshold, and is not just a mean of the total time segment's S.N.D. level at that frequency.

p(f) vs t :

('Frequency from N.C.F. (kHz)' vs 'The probability of an interfering signal' vs 'time')

This is a representation as a probability that a signal was above the S.N.D. threshold level during a time segment at a particular frequency. The calculation of the length of time that a signal at a particular frequency was above the threshold level during a time segment is used to derive the probability.

p(l) vs t :

('S.N.D. level (dBHz)' vs 'The probability of an interfering signal' vs 'time')

This is a representation as a probability that a signal was within the entire frequency range during a time segment at a particular S.N.D. level.

$$\begin{aligned} p(l) &= [1 - p(\text{no int. at level } l)] \\ &= [1 - \prod_i \{p(\text{no int. of freq. } i \text{ at level } l)\}] \end{aligned}$$

p(f|l) vs t, p(l|f) vs t :

These are specific cases of p(f) and p(l) respectively. They are p(f) given a particular S.N.D. level and p(l) given a particular frequency.

p(l>L) vs t :

('S.N.D. level (dBHz)' vs 'The probability of an interfering signal above S.N.D. level L' vs 'time')

This is a representation as a probability that a signal was within the entire frequency range during a time segment at a S.N.D. level greater than a particular S.N.D. level. This is the cumulative distribution of the p.d.f p(l).

AUTHORIZED USE

('Proportion of time an authorized user was using the channel' vs 'time')

The values for each discrete time segment can indicate the length of time monitoring was carried out for each time segment. This would be the opposite proportion of the authorized access time (e.g. if authorized accesses were monitored 30 % of a time segment then 70 % of the same time segment was used to monitor for interference).

4 Conclusion And Further Development

4.1 Conclusions

The conclusions presented here relate to the effectiveness of the system created and its usefulness from an operational point of view.

The system has been proved to work and it has been setup and used at short notice. The analysis produced by 'INTDISP' has been sufficient for the requirements to date. Thus the present system is adequate, but a review of its development possibilities is given.

The development of the system includes making an assessment of the present system and identifying any inefficiencies or restrictions. Two aspects can be considered, firstly the improvement of the system when operating under its initial requirement and secondly the development of the system to work in other less well defined situations.

4.2 Software Enhancements

As previously stated the system does fulfill its initial requirement, thus it can be assessed that no restrictions exist for this type of monitoring. The aspect of improving the efficiency has several points. The software itself has areas where more efficient coding could be introduced, e.g. the averaging of samples by the spectrum analyser could be triggered directly the previous sample has been read, thus the averaging process of the spectrum analyser could be concurrent with the quantization process of the software 'INTLOG'. Other improvements include the optimization of computing time for calculating the noise level, and this could be achieved by rewriting any computationally expensive code in Pascal and producing CSUBS that are accessible from BASIC.

The algorithm for calculating the noise level (using the L_1 norm) may be improved in certain circumstances by using norms other than the L_1 norm. Using values of less than one in the norm definition, (e.g. L_x norms where $x < 1$), produces some good approximations when applied to noise level estimation. The definition of these calculations are the same as with $x \geq 1$ but they are not valid norms as they do not obey the axioms of norms.

4.3 Software developments

The case of applying the system to other situations depends on there being enough flexibility to accept the requisite new parameters. The sampling parameters that define the spectrum analyser's acquisition and the quantization parameters, are adequately flexible to incorporate most sampling configurations. The restrictions that exist in the present system include the 15 minute monitoring periods, although this could easily be altered to accept any length of time.

Also the action of the software when an authorized access is present on the channel may not be desirable; the software ignores any sample where an authorized access is present. A more desirable response may be to just ignore the authorized access and monitor any interference in other parts of the channel, or even to include the authorized access in the monitoring, and then it can be viewed with the interference using 'INTDISP'. The model used to recognize an authorized access needs to be flexible, to incorporate any required signal pattern of S.N.D. against frequency.

APPENDIX A.

Finding The Noise Level Of A Channel

The noise level of a channel is taken as, the level which is a best fit to all the power levels measured, at all frequency components, using the non-Euclidian norm L_1 ($\| \cdot \|_1$).

where $\|A\|_1 = \sum a_i$

The minimization of this function is achieved using an optimization scheme, the Golden Section Search (GSS), optimizing for \hat{n} .

The GSS is analogous to the method of bisection for root finding, and has a similar convergence factor of approximately 1.3 (i.e. errors decrease as $\epsilon^{1.3}$, where ϵ is the error, at each iteration). The initial values for the GSS are taken as the minimum and maximum values of the measured power levels (obviously 'n' (the true noise level) must be bracketed by these values). Below is the format for the search algorithm (assuming the search is for a minimum error value).



At each power level (a, b, x_1, x_2) the value of the L_1 norm associated with each level compared with the channel is calculated.

e.g. $E(a) = \text{Min}[\sum |a - y_i|] = \epsilon a$

This gives a set of error values $(\epsilon_a, \epsilon_b, \epsilon_{x_1}, \epsilon_{x_2})$.

The value of 'E(x)' is an indication of how good a fit the level 'x' is to the channel, thus it is this value being minimized.

If $ex_2 > ex_1$ then x_2 and 'a' bracket the minimum
otherwise x_1 and 'b' bracket the minimum.

Thus the new bracketing pair are used for the next 'a' and 'b' in the second iteration. Only a single x value is required to be calculated in the second and subsequent iterations, as the x value not in the bracketing pair can be used as one of the internal x values, this due to the selection of β to satisfy this condition.

The iteration procedure is continued until the range between the two bracketing levels is to within a specified tolerance. This is normally set to 0.5 dB in the software.

APPENDIX B.

Converting From Power To Signal To Noise Density

Converting From Power Spectrum To S.N.D.

Initially the spectrum read from the spectrum analyser is adjusted to a relative measurement by subtracting the noise level.

i.e. $Y' = Y - \hat{n}$

\hat{n} = Linear power of noise level

Y = Linear power levels

Y' = Normalized Linear power levels

Then the signal to noise density is given by

$$SND = Y'/n_0$$

where $n_0 = \hat{n}/(1.2 \cdot r)$

r = Resolution bandwidth of the spectrum analyser

$1.2 \cdot r$ = The assumed noise bandwidth of the analyser filter [1]

[1] Reference - Hewlett Packard Spectrum Analyser Series, Application Note 150-4. Spectrum Analysis, Noise Measurements, April 1984.

APPENDIX C.

Determining A Level For Each User Defined Frequency Slot

Determining A Level For Each User Defined Freq Slot

The purpose of the software is to detect interferers, thus it is for this reason that the representation level for each frequency slot is taken as the maximum level found within that slot, indicating an interferer at that level.

The SND levels for each slot are then converted from a linear measurement to dBHz ($SND (dBHz) = 10 \cdot \log_{10}(SND (Lin))$). The values are recorded into a single dimensional array referenced by the appropriate frequency slot.

APPENDIX D.

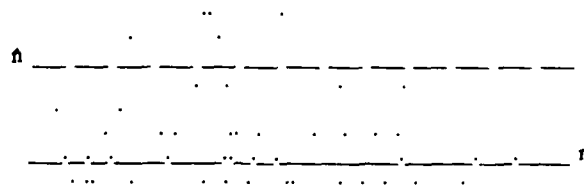
Comparison Of Norms For Measuring A Noise Level

Comparison Of Norms For Measuring A Noise Level

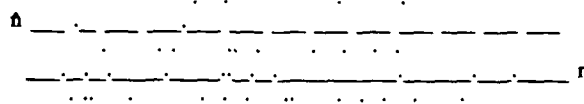
Below is a representation of the level that each of the listed norms, if used as the best fit criterion, would estimate as the noise level in a channel with interference present.

n = the mean noise level
 \hat{n} = estimated noise level
 Y = measured power levels of channel

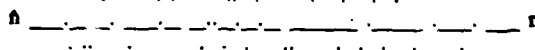
L_∞ norm ($\|\cdot\|_\infty$) - Chebyshev approximation (minimax)
 $\text{Min}\|\hat{n}-Y\|_\infty = \text{Min}[\text{Max}|\hat{n}-y_i|]$



L_2 norm ($\|\cdot\|_2$) - Least squares approximation
 $\text{Min}\|\hat{n}-Y\|_2 = \text{Min}[\sum((\hat{n}-y_i)^2)]$



L_1 norm ($\|\cdot\|_1$)
 $\text{Min}\|\hat{n}-Y\|_1 = \text{Min}[\sum|\hat{n}-y_i|]$



APPENDIX E.

Software Statistics

'INTLOG' - Monitoring Software

Program Segment	Size (bytes)	Code Language
MAIN	6142	BASIC
Initreset	1158	BASIC
Vidave	978	BASIC
Readta	508	BASIC
Setref	1058	BASIC
Analysis	1246	BASIC
Coursefreq	1688	BASIC
Linear	516	BASIC
FNLin	344	BASIC
FNCheckautuse	810	BASIC
FNMeannoise	1642	BASIC
FNLinorm	602	BASIC
Logints	730	BASIC
Setupcalib	1426	BASIC
Calparams	2222	BASIC
Null	244	BASIC
Dispcalib	1982	BASIC
Aveparams	1868	BASIC
Setupusr	2828	BASIC
Dispusr	1228	BASIC
Disptime	304	BASIC
Strdefaults	852	BASIC
Readefaults	1160	BASIC
Graphs	956	BASIC
Rstdtfcts	610	BASIC

Total size of 'INTLOG' = 33102 bytes

Totals number of lines of code = 758

'INTDISP' - Statistical Analysis Software

Program Segment	Size (bytes)	Code Language
MAIN	4300	BASIC
Rdatafs	1336	BASIC
Graphs3d	7806	BASIC
Readata	960	BASIC
Defface	660	BASIC
Null	352	BASIC
Readmsdata	612	BASIC
Analysis	2782	BASIC
Choutput	4158	BASIC
Parameters	7014	BASIC
Deftemp	4310	BASIC
Table	5262	BASIC
Graphs2d	4846	BASIC
Display	4494	BASIC
Setuvwxzya	482	BASIC

Total size of 'INTDISP' = 49374 bytes

Totals number of lines of code = 1416

APPENDIX E.

Example Of Input Parameters For 'INTLOG'

<p align="center">AUTOMATIC INTERFERENCE MONITORING (Calibration parameters)</p>
--

Center frequency MHz
Frequency Range -17.5 KHz from NCF to + 17.5 KHz in 2.5 KHz steps
Resolution Bandwidth 1 KHz
Video Bandwidth 1 KHz
Sweep 300 msec

Number of video averages is 20

Threshold level for sig noise dnsty monitoring is 30 dBHz
Max sig noise dnsty above threshold level is 40 dBHz
Resolution of sig noise dnsty level is 2 dBHz

CHANGE PARAMS						
		UPDATE DEFAULT		CONTINUE		*

Figure F.1 - Display Of Calibration Parameters

	ZULU TIME
	12:10:27
	24 Mar 1988

<p align="center">AUTOMATIC INTERFERENCE MONITORING (User parameters)</p>

Filename prefix -
(No file name implies data will not be stored)

Start time of monitoring - 12:15:00 24 Mar 1988
Duration of monitoring (number of 1/4 hrs) - 96
finish time of monitoring - 12:15:00 25 Mar 1988

ZULU TIME	ZULU DATE	START TIME	FINISH TIME	
FILE NAME	NUM INTERVALS	START DATE	FINISH DATE	CONTINUE

*

Figure F.2 - Display Of User Parameters

APPENDIX G.

Example Of Display For 'INTLOG'

<p>-----</p> <p>AUTOMATIC INTERFERENCE MONITORING</p> <p>-----</p>		<p>ZULU TIME</p> <p>13:49:18</p> <p>24 Mar 1988</p>
--	--	---

*** MONITORING ***

<p>Last Period Int Monitored - 87 % of time</p> <p>Last sampled recorded</p> <p>INTERFERENCE ON THE CHANNEL</p>	<p>Period - 1 out of 95</p> <p>This period began - 13:45:00</p> <p>and finishes - 14:00:00</p> <p>Data file - 1</p> <p>S.N.D. Threshold - 30 dBHz</p> <p>S.N.D. Resolution - 2 dBHz</p> <p>C.F. -</p> <p>Freq Span - 40 KHz</p>
---	---

Figure G.1 - Display From 'INTLOG' Having Monitoring Interference

<p>-----</p> <p>AUTOMATIC INTERFERENCE MONITORING</p> <p>-----</p>		<p>ZULU TIME</p> <p>14:02:28</p> <p>24 Mar 1988</p>
--	--	---

*** MONITORING ***

<p>Last Period Int Monitored - 87 % of time</p> <p>Last sampled recorded</p> <p>AN AUTHORIZED ACCESS ON THE CHANNEL</p>	<p>Period - 2 out of 95</p> <p>This period began - 14:00:00</p> <p>and finishes - 14:15:00</p> <p>Data file - 2</p> <p>S.N.D. Threshold - 30 dBHz</p> <p>S.N.D. Resolution - 2 dBHz</p> <p>C.F. -</p> <p>Freq Span - 40 KHz</p>
---	---

Figure G.2 - Display From 'INTLOG' Having Monitoring An Authorized Access

APPENDIX H.

Example Of Analysis Parameters For 'INTDISP'

Data Parameters

Time Span from - 18:00:00 16 Feb 1988
to - 16:30:00 17 Feb 1988
In 1/4 hour steps

Variable Parameters For Data Output

Range of SMD level - 30 dBHz
to - 70 dBHz
In - 2 dBHz steps

Time Span, Start - 18:00:00 16 Feb 1988
Finish - 16:30:00 17 Feb 1988
Time inc - 1 1/4 hours

NCF - MHz
Freq span - 20 KHz +/- NCF
Step size - 2.5 KHz

Threshold - 30 dBHz
Max tabulated level - 68 dBHz
Max SMD used for calc's - 70 dBHz
(Step size = 2 dBHz)

Acquisition Details :-
Video average - 20
Video bandwidth - 1
Sweep time - 300

Freq span, Start - 17.5 KHz
Finish - 17.5 KHz

START TIME	}	THRESHOLD	{START FREQ	TIME INC
FINISH TIME	MAX TAB LEVEL	MAX SMD	FINISH FREQ	SET

Figure H.1 - Display Of Data And Variable
Parameters From 'INTDISP'

APPENDIX I

Examples Of Output Statistics From 'INTDISP'

FREQUENCY vs MEAN LEVEL OF INTERFERER ABOVE THRESHOLD vs TIME

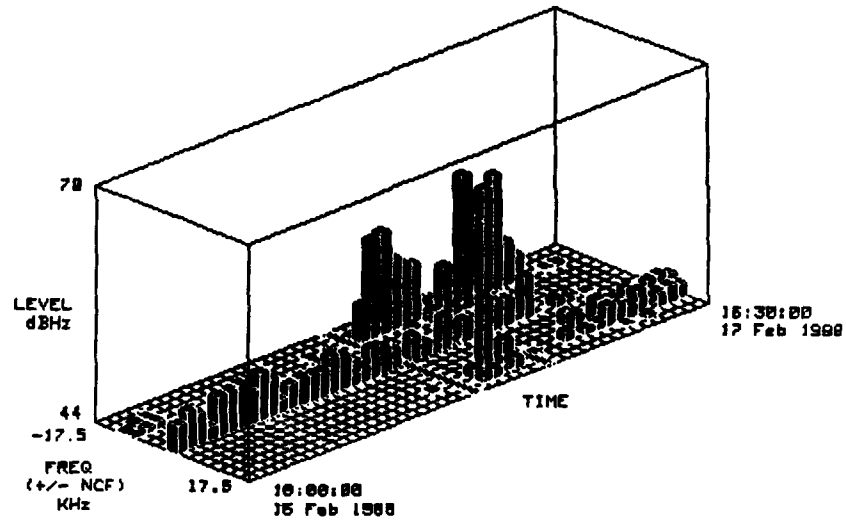


Figure I.1 - 3D Graph Representation

FREQUENCY vs MEAN LEVEL OF INTERFERER ABOVE THRESHOLD vs TIME

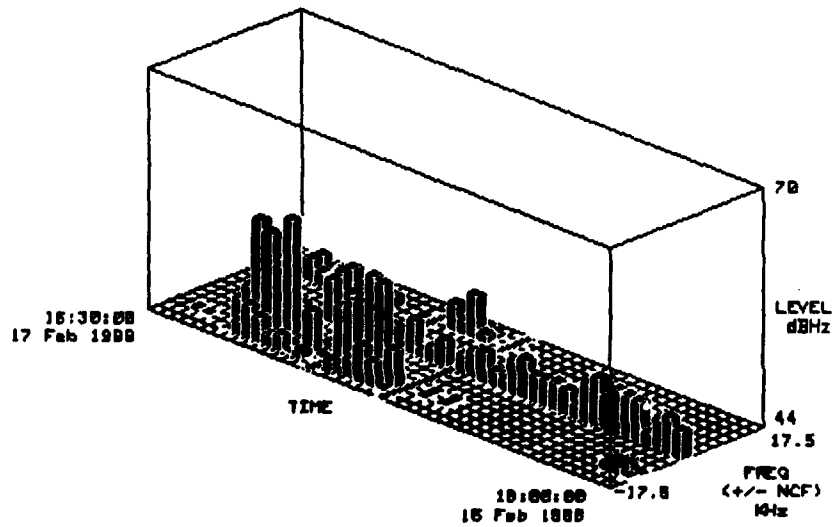


Figure I.2 - Left Hand Projection Of Fig I.1

INTERFERER LEVEL vs PROBABILITY OF INTERFERER GREATER THAN L (CDF)
 (-17.5 < FREQ < 17.5 kHz OF NCF) vs TIME

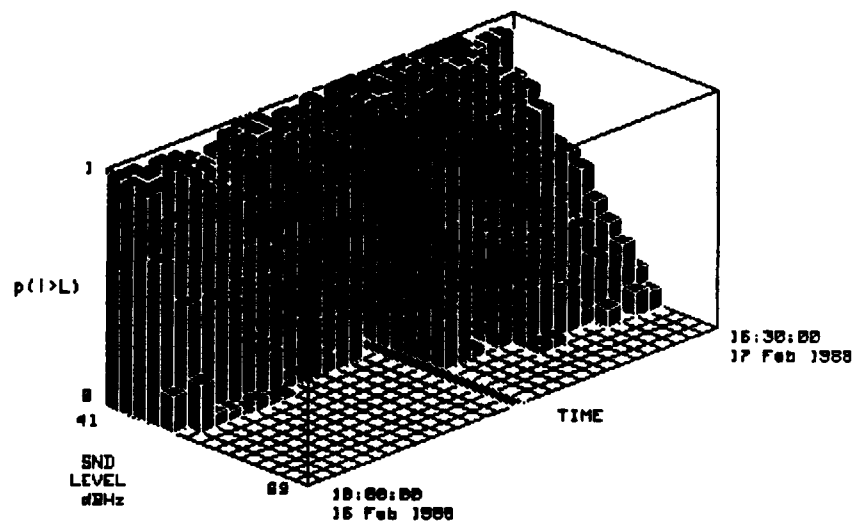


Figure 1.3 - Example Of A Cumulative Distribution

INTERFERER LEVEL vs PROBABILITY OF INTERFERER GREATER THAN L (CDF)
 (-12.5 < FREQ < -12.5 kHz OF NCF) vs TIME

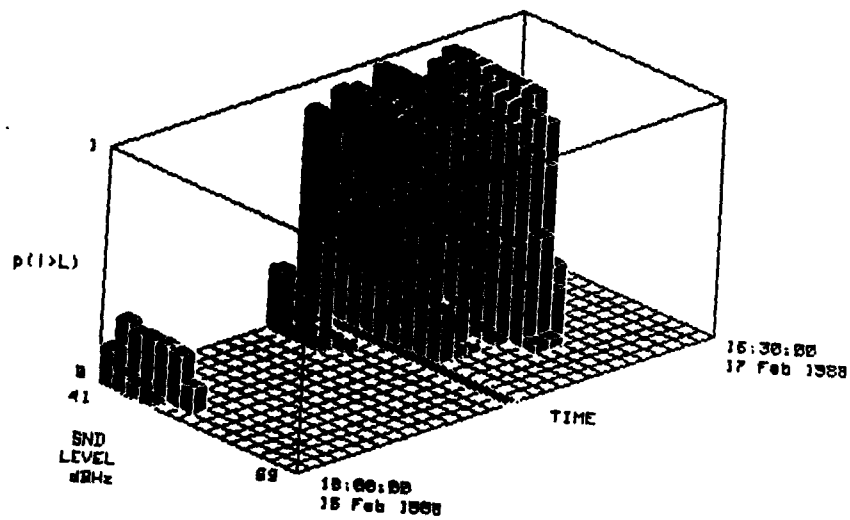
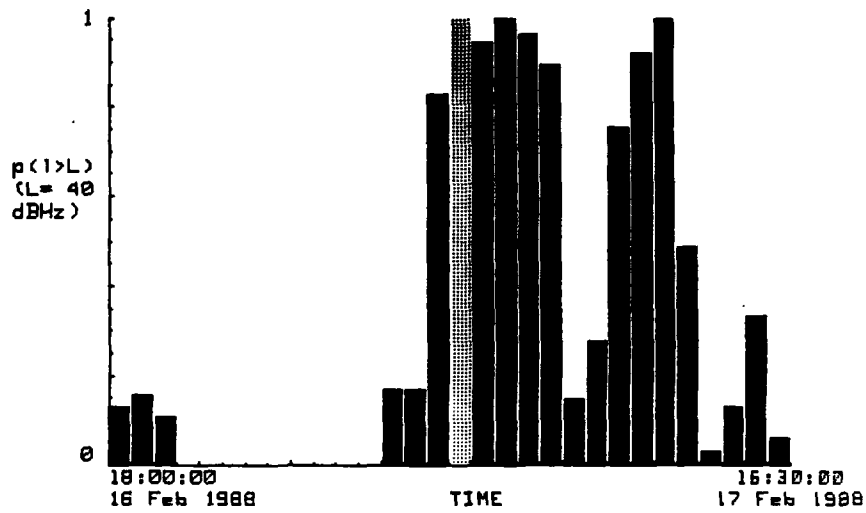


Figure 1.4 - As Fig. 1.3 With The Frequency Range Reduced To A Single Frequency Slot

PROBABILITY OF INTERFERER AT LEVEL GREATER THAN 40 dBHz
 ($-12.5 < \text{FREQ} < 12.5$ KHz OF NCF) vs TIME



PROPORTION OF TIME IN A PERIOD THAT
AN AUTHORISED ACCESS WAS PRESENT

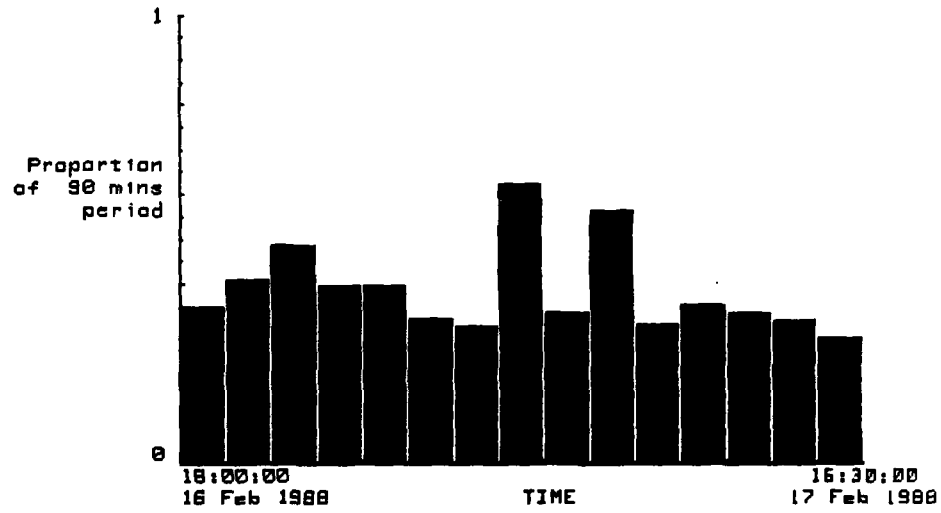


Figure I.6 - An Example Of Authorized Use Analysis

PROBABILITY OF AN INTERFERER GREATER THAN A LEVEL
(-12.5 < FREQ < 12.5 KHz OF NCF) vs TIME

TIME	PROBABILITY OF INTERFERER AT LEVEL (dBHz > THRESHOLD)											
	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0	56.0	58.0	60.0	62.0
16 Feb 1988												
18:00:00	.215	.099	.076	.026	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18:30:00	.174	.174	.174	.174	.174	.091	0.0	0.0	0.0	0.0	0.0	0.0
19:00:00	.246	.202	.202	.202	.180	.081	0.0	0.0	0.0	0.0	0.0	0.0
19:30:00	.134	.056	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20:00:00	.091	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17 Feb 1988												
00:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
00:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
01:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
01:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03:00:00	.384	.245	.103	.026	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03:30:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04:00:00	.315	.102	.052	.052	.026	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04:30:00	.896	.375	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05:00:00	****	****	****	****	****	****	****	****	****	****	****	****
05:30:00	.742	.704	.688	.608	.473	.377	.306	.154	0.0	0.0	0.0	0.0
06:00:00	.943	.941	.941	.941	.941	.936	.926	.813	.210	0.0	0.0	0.0
06:30:00	.949	.949	.949	.949	.948	.942	.895	.601	.158	0.0	0.0	0.0
07:00:00	.938	.938	.938	.932	.887	.737	.343	0.0	0.0	0.0	0.0	0.0
07:30:00	.872	.840	.820	.797	.763	.703	.567	.279	.029	0.0	0.0	0.0
08:00:00	.907	.899	.867	.820	.779	.738	.447	0.0	0.0	0.0	0.0	0.0
08:30:00	****	****	****	****	****	****	****	****	****	****	****	****
09:00:00	.239	.049	.049	.049	.049	.049	.049	.049	.025	0.0	0.0	0.0
09:30:00	.481	.481	.481	.481	.481	.481	.481	.481	.467	.302	.053	0.0
10:00:00	.216	.194	.173	.150	.150	.150	.150	.150	.127	.053	0.0	0.0
10:30:00	.946	.944	.944	.944	.944	.944	.944	.940	.916	.635	.051	0.0
11:00:00	.833	.828	.828	.823	.817	.817	.817	.806	.529	0.0	0.0	0.0
11:30:00	.897	.894	.890	.890	.884	.864	.847	.802	.653	.286	0.0	0.0
12:00:00	.971	.971	.971	.971	.971	.966	.914	.400	0.0	0.0	0.0	0.0
12:30:00	.904	.889	.746	.550	.550	.550	.538	.308	0.0	0.0	0.0	0.0
13:00:00	.516	.516	.474	.427	.427	.427	.427	.243	0.0	0.0	0.0	0.0
13:30:00	.084	.029	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14:00:00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14:30:00	.329	.234	.098	.025	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15:00:00	.425	.208	.143	.121	.050	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15:30:00	.225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16:00:00	.025	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure I.7 - An Example Of Tabulated Output

DOCUMENT CONTROL SHEET

Overall security classification of sheet UNCLASSIFIED

(As far as possible this sheet should contain only unclassified information. If it is necessary to enter classified information, the box concerned must be marked to indicate the classification eg (R) (C) or (S))

1. DRIC Reference (if known)	2. Originator's Reference MEMO 4243	3. Agency Reference	4. Report Security U/C Classification	
5. Originator's Code (if known) 7784000	6. Originator (Corporate Author) Name and Location ROYAL SIGNALS AND RADAR ESTABLISHMENT ST ANDREWS ROAD, GREAT MALVERN, WORCESTERSHIRE WR14 3PS			
5a. Sponsoring Agency's Code (if known)	6a. Sponsoring Agency (Contract Authority) Name and Location			
7. Title AUTOMATIC COMMUNICATIONS CHANNEL INTERFERENCE MONITORING				
7a. Title in Foreign Language (in the case of translations)				
7b. Presented at (for conference papers) Title, place and date of conference				
8. Author 1 Surname, initials SMITH, N G	9(a) Author 2	9(b) Authors 3,4...	10. Date 1988.04	pp. ref. 41
11. Contract Number	12. Period	13. Project	14. Other Reference	
15. Distribution statement				
Descriptors (or keywords)				
continue on separate piece of paper				
<p>Abstract</p> <p>This memorandum describes a system that monitors a communications channel and logs details of interfering signals. An overview of the system hardware configuration and a detailed description of the software is provided. The system consists of software for logging signals that occur in the channel and independent software for analysis of the logged data.</p> <p><i>(G2081 B2001)</i> <i>(121)</i></p>				